Chapter 3

Power Transmission and Distribution:

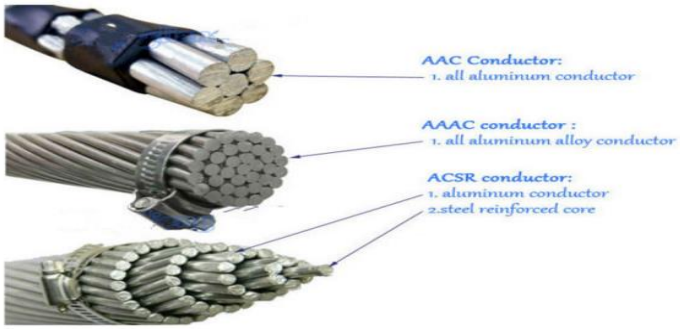
1. Electricity is generated at generating stations and is transmitted to the places over long distances where it is consumed.
2. Based on how the electrical conductors are laid, the transmission or distribution systems are known as Over Head (OH) or Under Ground (UG) systems.
3. Overhead conductors are generally bare electrical conductors (without insulation) supported by tall structures such as towers or poles.
4. Underground Cables are conductors or bunch of conductors covered with electrical insulator and are buried underground.

Overhead Cables Overhead Cables:

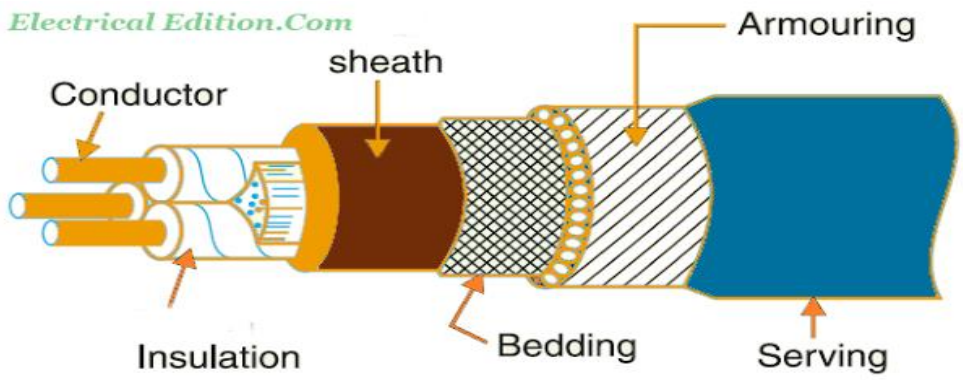
→ Number and size of strands of the conductor depends on current to be carried.

→ Strands used in place of single conductor help reduce the ac resistance of the conductor.

1. AAC: All Aluminum Conductors .High Corrosion resistance. Used for short spans. Best electrical performance but mechanical strength is poor.
2. AAAC: All Aluminum Alloy Conductors. Good mechanical strength and electrical performance.
3. ACSR: Aluminum Core Steel Reinforced conductors are used for better mechanical strength. Used for extra-long span.



Underground Cables:



Part of Underground cable	Functions as	Material Used
Cores or Conductors	Carries current.	Copper Aluminum
Insulation	Stop the leakage of current	Paper Rubber
Metallic sheath	To protect the insulation from direct contact with the soil	Aluminum
Bedding	It protects the metallic sheath from corrosion due to moisture and it Acts as adhesive to stick the metallic sheath and armoring.	Jute Hessian Tape
Armoring	Provide good mechanical strength to the cable and to protect the cable from injuries during erection	Galvanized Steel Wire Steel Tape
Serving	Protect armoring from atmospheric conditions	Jute

Particular	Overhead	Underground
Public safety	Less safe	More safe
Initial Cost	Less expensive.	More expensive
Faults	Faults occur frequently	Rare chances of fault
Appearance	Shabby look	Does not disturb the view as cables are hidden underground
Flexibility	More flexible as new conductors can be laid along the existing conductors	New channels are required to laydown new cables.
Location of fault	Fault location can be identified easily by visual inspection.	Special techniques are required to locate fault.
Repair	Repairing is easy and less expensive	Repairing is difficult. Requires special arrangements for joining cables.
Working Voltage	Can be used for any value of high voltage.	It has limitations of insulation difficulty

Advantages of UG Cables:

1. High level of personal and public safety.

2. No bushfire problems.

3. Minimal lightning problems.

4. Not affected by ice, snow, rain, wind, dust, smoke or fog

5. Not affected by storms, hurricanes, tornados.

6. Less number of faults, hence low maintenance cost.

7. Value of land and building unaffected.

8. High reliability and availability.

9. Reduced T and D losses.

10. Low Electro Magnetic Field

11. No Corona discharge, Radio Interference, Television Interference.

Disadvantages of UG Cables:

1. Digging of continuous trench is essential.

2. Presence of vaults and manholes.

3. High cost of installation.

4. High cost of Maintenance and repair as cables and their installation is expensive.

5. Longer outage time to locate fault and repair.

6. Soil thermal conditions are modified.

Corona Discharge:

1. The phenomenon of violet glow, hissing noise and production of ozone gas in an overhead transmission line is known as corona.
2. Partial discharge of electrical energy which causes the ionization of air close to the conductors in Extra High voltage (EHV) transmission lines is known as Corona Effect.

Factors Affecting corona:

1. Line voltage
2. Spacing between the conductors
3. Conductor Size
4. Atmospheric conditions

Methods of reducing corona effect:

1. By increasing conductor size
2. By increasing conductor spacing

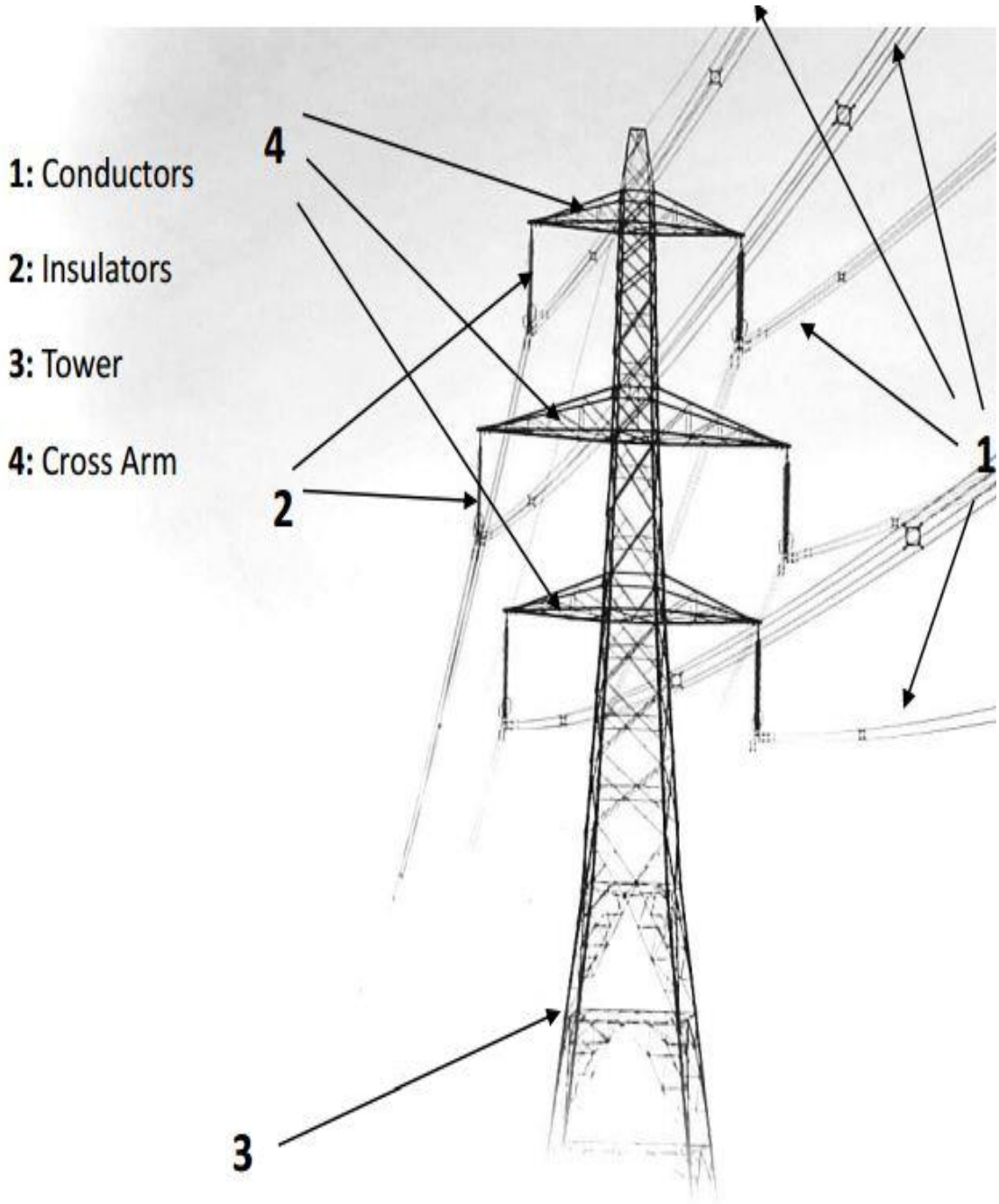
Advantages of corona:

1. Due to corona formation, the air surrounding the conductor becomes conducting and hence virtual diameter of the conductor is increased. The increased diameter reduces the electrostatic stresses between the conductors.
2. Corona reduces the effects of transients produced by surges.

Disadvantages of corona:

1. Corona is accompanied by a loss of energy. This affects the transmission efficiency ↓ of the line.
2. Ozone is produced by corona and may cause corrosion of the conductor due to chemical action.
3. The current drawn by the line due to corona is non-sinusoidal and hence non sinusoidal voltage drop occurs in the line. This may cause inductive (flux) interference with neighboring communication lines.

Components of Overhead Transmission Line:



Supporting Structure: Towers and Poles:

The supporting structure must have following properties

1. High mechanical strength to support the weight of the conductor.
2. Light in weight to be transported easily.
3. Cheap in cost and economical to use and maintain.
4. Longer life
5. Easy accessibility of conductors for maintenance.

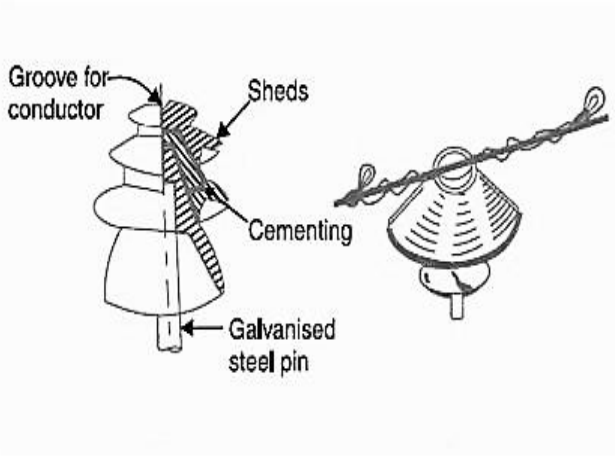
Insulators:

The insulators provide necessary insulation between line conductors and supports and thus stop any leakage current from conductor to earth.

The insulators should have following properties:

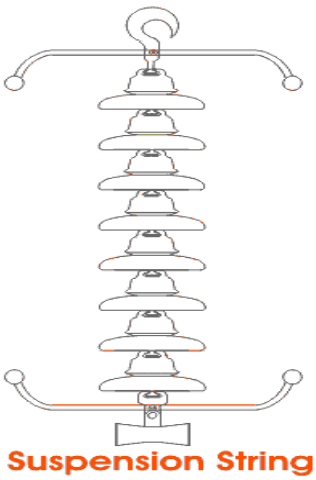
1. High electrical resistance to avoid any leakage current.
2. High relative permittivity (ε_r) so as to reduce capacitance effect.
3. High mechanical strength in order to withstand conductor load and wind load etc.
4. Non-porous, free from impurities and cracks.
5. Able to withstand severe atmospheric conditions such as heat and moisture.

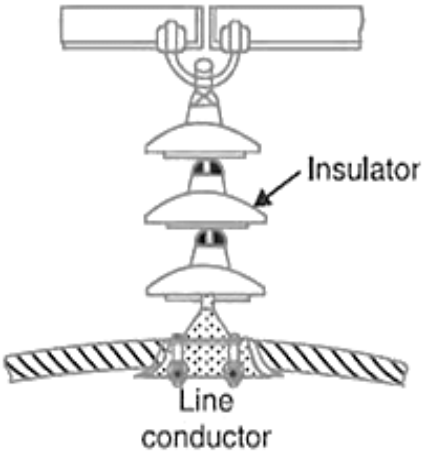
1-Pin Type Insulator:



1. There is a groove on the upper end of the insulator for housing the conductor.
2. The conductor passes through this groove and is bound by wire of material same as that of the conductor.
3. These are used for transmission or distribution lines up to 33kV.
4. For voltage more than33kV the pin type insulators become too bulky.

2-Suspension OR Disc Type Insulator:



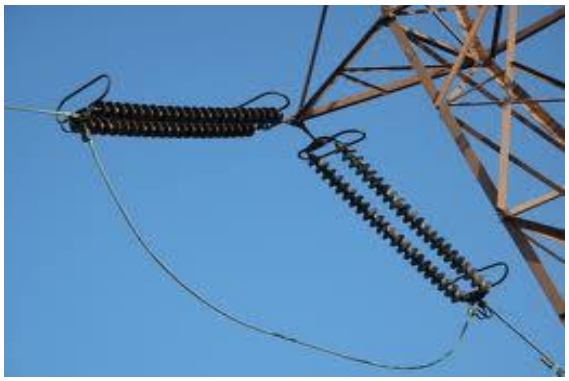


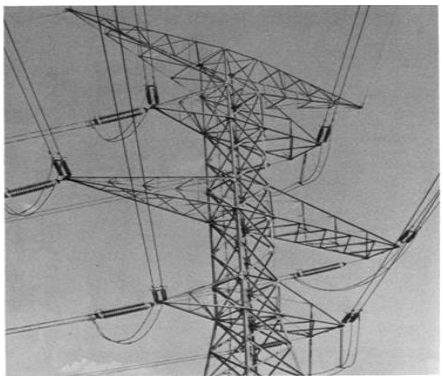
1. These have number of porcelain discs connected in series by metal links in the form of string. The conductor (lower) is suspended at the bottom end of the string while the other end of the string is fixed to the cross arm of the tower (upper) .
2. If anyone disc is damaged, only the damaged one is replaced.
3. Generally each of the discs is designed to withstand 11 kV.
4. Offers flexibility to the line to reduce mechanical stresses.
5. These are cheaper than pin type insulators for voltages more than 33kV.

3-Shackle OR Spool Type Insulator:

1. These are the insulators used where there is a dead end of the line or there is corner or sharp curve.
2. Shackle insulators are used as strain insulators for voltages up to 11 kV.

4-Strain Type Insulator:



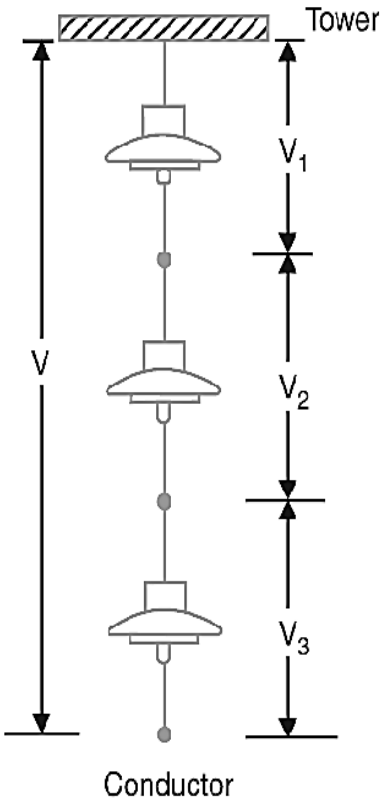


1. Where there is a dead end of the line or there is corner or sharp curve, the line is subjected to greater tension. In order to relieve the line of excessive tension, strain insulators are used.

2. For low voltage lines shackle insulators are used as strain insulators. However for high voltage transmission lines, suspension insulators are used as strain insulators.

3. When the tension is excessively high, two or more strings are used in parallel.

String Efficiency:



1. Voltage across the string of suspension insulators is not uniformly distributed across the individual discs.

2. The disc nearest to the conductor has highest voltage across it whereas the disc attached with the cross arm has lowest voltage.
   V1<V2<V3<V4

3. This phenomenon is undesirable and is expressed in terms of string efficiency.

4. String efficiency is improved by using longer cross arms, by grading the insulators, by using a guard ring.

$$String\ Efficiency = \frac{Voltage\ across\ the\ string}{n \times Voltage\ across\ disc\ nearest\ to\ the\ conductor} \times 100$$

$$\eta = \frac{(V1 + V2 + V3) or Vph}{n \times V3} \times 100$$

Where, *n* = number of discs in the string

1-A 3-phase transmission line is being supported by three disc insulators. The potentials across top unit (i.e., near to the tower) is 8 kV, middle unit is 11 kV, and lowest unit is 18.12 kV. Calculate

1. Voltage across string.

2. Line voltage

3. String efficiency.

2-A three phase transmission line is being supported by 4 disc insulators and the total voltage across the string is 30 kV. The potentials across top unit (ie: disc nearest to tower) is 6kV, next disc is 8 kV and lowest unit (i.e.: disc nearest to conductor) is 9 kV. Find:

1. Disc voltage

2. Line voltage

3. String efficiency.

3-If the string efficiency of a three phase transmission line is 70% and it is supported by 5 disc insulators. The potentials across top unit (i.e.: disc nearest to tower) is 5kV, next disc is 7kV, next disc is 8 kV, and lowest unit (i.e.: disc nearest to conductor) is 12 kV. Find

1. The voltage between line and earth

2. Line voltage

3. The disc voltage.

Basic idea of AC and DC power transmission:

Transmission circuits can be of many varieties based on type of supply, and load requirements.

Types of transmission circuits:

DC System:

→ DC two Wire

→ DC two wire with midpoint earthed

→ DC three wire Single Phase

AC System:

→ Single phase two wire

→ Single phase two wire with mid-point earthed

→ Single phase three wire

Three phase AC System:

→ Three phase three wire (L1 , L2 , L3)

→ Three phase four wire (L1 , L2 , L3 and N)

→ Three phase three wire system requires minimum volume of conductor per watt of power to be transmitted.

→ Three phase three wire system is hence the most popularly used for transmission purpose.

→ Three phase four wire system however is used generally for distribution purpose.

1) First advantage of the three phase four wire system is that there are two voltage levels available.

a) Line to line (line) voltage

b) Line to neutral (phase) voltage.

2) Second advantage is that, three phase and also single phase supply can be obtained from the same set of wires.

Load factor:

→ It is the ratio of the Actual Load to Full load

→ Load Factor=Actual Load / Full Load

→ The Load factor is always <=1

Diversity factor:

→ Diversity Factor = Installed load / Running load.

→ The diversity factor is always >= 1

Power factor:

→ It is the cosine of the angle between voltage and current.

Disadvantages of low power factor:

1. Large KVA rating

2. Greater conductor size

3. Large copper losses

4. Poor voltage regulation

Power factor improvement methods↑:

1. Static capacitors

2. Synchronous condensers

3. Phase advancers